ACE

ADC BioScientific Ltd.

Automated Soil CO_2 Exchange System

ACE Station

Independent Station for automated soil CO_2 flux measurements, data-logging and secure data storage

Soil chamber options

- Small chamber for open mode
- Large chamber for closed mode
- Transparent or opaque chambers

ACE Master Controller

Up to 30 ACE Stations may be linked to a Master Controller, forming an ACE Network

Sensors

Connect multiple sensors for soil temperature and soil moisture

Function:

Automatically covers the soil, measures soil CO_2 flux, then opens to re-expose soil to ambient conditions after each measurement is completed.

Measurement Technique:

Time intervals, or required differential CO_2 values between automatic measurements are user-set in either an open or closed system ACE Station.

A single ADC CO_2 IRGA is housed directly next to the soil analysis area to provide highly accurate data.

Application:

Worldwide, in diverse and often harsh environments.

Examples from published papers include:

- Tillage vs no-tillage agriculture in Slovak Republic
- Mid-boreal and subarctic soils in Canada
- Wheat/maize crops in China
- Lawn soils in urban areas
- Paddy fields in China
- Antarctic vegetation

ACE Station

Each ACE Station is a complete, fully integrated soil CO_2 flux analysis system comprising a soil chamber, heat reduction parasol and arm that pivots from the control console, where measurements are both displayed and recorded.

Each ACE Station operates independently for data collection and logging.

An external power source with an output voltage of 12-40VDC is required. A 40Ah car battery will power an ACE Station for around 28 days (based on measurement frequency of once per hour). The power efficient ACE Station can be powered continuously by battery, with solar panel or wind turbine.

Long-term unattended operation:

The automated design of the ACE Station allows the soil area to be exposed to ambient conditions between measurement cycles.

At user-set time intervals, the chamber will automatically cover the soil to carry out measurements. Once these measurements are completed, the chamber will automatically re-expose the soil area.

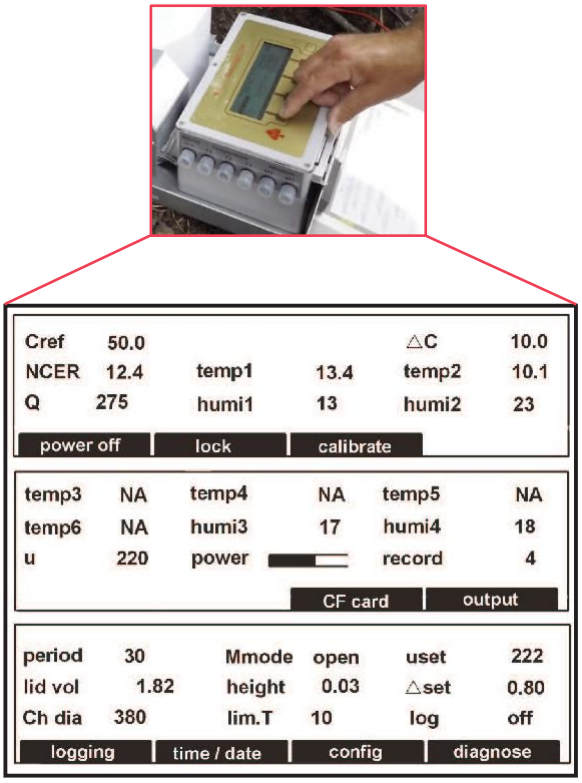
The novel “swinging arm” mechanism is proven to be reliable, field rugged and to ensure a consistent seal when the chamber is covering the soil.

When the chamber is in the exposed position, the ACE Station enters a low power consumption mode.

Easy to install and program:

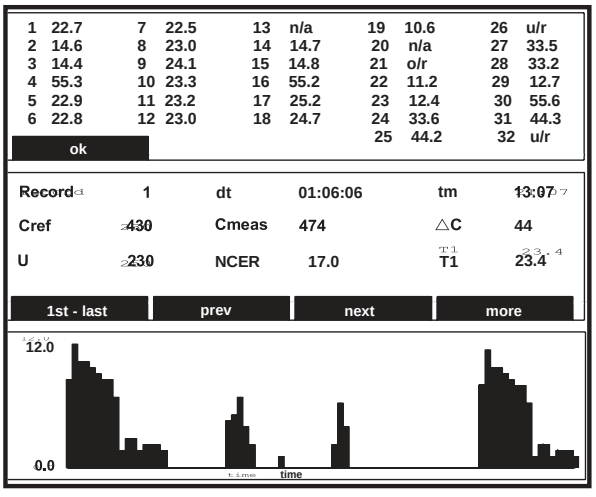
The ACE Station is easy to set up and program.

The control console features a large display screen. Programming is achieved using just 5 keys to drive a series of intuitive menus.



Data Logging:

Gas exchange measurements, soil flux calculations and sensor measurements are all displayed and recorded by the ACE Station.
Data is stored internally and can be accessed by SD card or USB cable.



Open and Closed system modes:

ACE Stations are available in either a closed or an open system configuration.

In both measurement modes, with the chamber in the covered position, a ΔCO_2 value is determined from the difference between the reference gas entering the chamber and the analysis gas within the chamber at the end of the experiment.

Transparent versions of both the open and closed chambers are available for measuring net CO_2 exchange within the chamber area. In applications of high photosynthetic activity, open mode transparent chambers are recommended.

Closed Mode:

A measurement is made once the chamber is sealed. CO_2 inside the large 2.6L chamber will then increase according to soil activity. The rate of soil flux is determined from the ΔCO_2 after a user-defined time interval.

These measurements are simple and fast.

Open Mode:

When the chamber seals, ambient air is passed through the smaller 1.0L chamber at a controlled flow rate.

Soil CO_2 flux is then determined at equilibrated conditions within the chamber. These measurements, although slower, are regarded as more accurate by many researchers as they are less influenced by changes within the enclosed chamber or variations in the soil structure.
The open chamber is designed with a pressure release valve and fan to minimise any internal pressure gradients.

An open system ACE Station may also be used in a closed mode by fitting a closed system chamber head.

Automatic calibration:

Every ACE Station is fitted with Zero/Ambient CO_2 concentration re-calculation for accurate NCER values.

Flux, moisture and temperature data:

Soil flux is expressed as Net CO_2 exchange rate (NCER) in µmol m^{-2} sec^{-1}.

In addition to the CO_2 exchange data a PAR sensor is provided, mounted on the ACE Station chamber.

As many as 6 soil temperature sensors and 4 soil moisture sensors may also be directly connected to each ACE Station. Sensor measurements are displayed and recorded alongside the gas exchange and soil flux data.

ACE Network

Although an ACE Station will function independently at a single sample location, it is typical that a number of Stations will be used in combination, as a Network deployed across a field site.

As many as 30 ACE Stations can be connected together in an ACE Network via an ACE Master control unit. This Master control unit will supply power to and collect data from all Stations within the network.

The ACE Master control unit is connected to each ACE Station by electrical cable only. Each ACE Station can be a maximum of 100 meters away from the Master control unit.

Individual ACE Stations can be removed from, or added to, the ACE network without interrupting data collection.

ACE Master

The ACE Master control unit is a waterproof, steel enclosure featuring a graphic display, CompactFlash card drive, a maximum of 30 ACE Station docking ports and 2 battery ports.

ACE Master control unit is available in 3 options with either 10, 20 or 30 ACE Station docking ports.

Programming control of an ACE Network is achieved using just 5 keys to drive a series of intuitive menus.

The ACE Master control unit monitors all Stations within the experimental network and flags any problems encountered.

The graphic display may be used to review and plot experiments in the field. For example:

- One Station, all parameters, one time point
- One parameter, one time point, all Stations
- One Station, one parameter, all time points

Power is via 12V or 24V batteries or a suitable alternative supply.

Selected publications:

1. Wu, Y. S., Li, X. R., Jia, R. L., Yin, R. P., & Liu, T. J. (2023). **Livestock trampling regulates the soil carbon exchange by mediating surface roughness and biocrust cover**. *Geoderma*, *429*, 116275. https://doi.org/10.1016/J.GEODERMA.2022.116275
2. Cannone, N., Ponti, S., Christiansen, H. H., Christensen, T. R., Pirk, N., & Guglielmin, M. (2019). **Effects of active layer seasonal dynamics and plant phenology on CO_2 land-atmosphere fluxes at polygonal tundra in the High Arctic, Svalbard**. *CATENA*, *174*, 142–153. https://doi.org/10.1016/J.CATENA.2018.11.013
3. Berglund, Ö., Kätterer, T., & Meurer, K. H. E. (2021). **Emissions of CO_2, N_2O and CH_4 From Cultivated and Set Aside Drained Peatland in Central Sweden**. *Frontiers in Environmental Science*, *9*, 630721. https://doi.org/10.3389/FENVS.2021.630721/BIBTEX
4. Badraghi, A., Novotná, B., Frouz, J., Krištof, K., Trakovický, M., Juriga, M., Chvila, B., & Montagnani, L. (2023). **Temporal Dynamics of CO2 Fluxes over a Non-Irrigated Vineyard**. *Land 2023, Vol. 12, Page 1925*, *12*(10), 1925. https://doi.org/10.3390/LAND12101925
5. Ibrahim, M. M., Guo, L., Wu, F., Liu, D., Zhang, H., Zou, S., Xing, S., & Mao, Y. (2022). **Field-applied biochar-based MgO and sepiolite composites possess CO_2 capture potential and alter organic C mineralization and C-cycling bacterial structure in fertilized soils**. *Science of The Total Environment*, *813*, 152495. https://doi.org/10.1016/J.SCITOTENV.2021.152495
6. Berglund, Ö., Berglund, K., Jordan, S., & Norberg, L. (2019). **Carbon capture efficiency, yield, nutrient uptake and trafficability of different grass species on a cultivated peat soil**. *CATENA*, *173*, 175–182. https://doi.org/10.1016/J.CATENA.2018.10.007
7. Czubaszek, R. (2019). **Exchange of Carbon Dioxide between the Atmosphere and the Maize Field Fertilized with Digestate from Agricultural Biogas Plant**. *Journal of Ecological Engineering*, *Vol. 20*(nr 1), 145–151. https://doi.org/10.12911/22998993/93798
8. Krištof, K., Šima, T., Nozdrovický, L., & Findura, P. (2014). **The effect of soil tillage intensity on carbon dioxide emissions released from soil into the atmosphere**. *Agronomy Research*, *12*(1), 115–120. https://agronomy.emu.ee/wp-content/uploads/2014/05/2014_1_12_b5.pdf#abstract-3114
9. Liu, Y., Wan, K. yuan, Tao, Y., Li, Z. guo, Zhang, G. shi, Li, S. lai, & Chen, F. (2013). **Carbon Dioxide Flux from Rice Paddy Soils in Central China: Effects of Intermittent Flooding and Draining Cycles**. *PLoS ONE*, *8*(2). https://doi.org/10.1371/journal.pone.0056562
10. Startsev, N., Bhatti, J. S., & Jassal, R. S. (2016). **Surface CO_2 exchange dynamics across a climatic gradient in McKenzie Valley: Effect of landforms, climate and permafrost**. *Forests*, *7*(11). https://doi.org/10.3390/f7110279
11. Zhao, P., Pumpanen, J., & Kang, S. (2020). **Spatio-temporal variability and controls of soil respiration in a furrow-irrigated vineyard**. *Soil and Tillage Research*, *196*. https://doi.org/10.1016/j.still.2019.104424
12. Zornoza, R., Rosales, R. M., Acosta, J. A., de la Rosa, J. M., Arcenegui, V., Faz, Á., & Pérez-Pastor, A. (2016). **Efficient irrigation management can contribute to reduce soil CO_2 emissions in agriculture**. *Geoderma*, *263*, 70–77. https://doi.org/10.1016/j.geoderma.2015.09.003

Online resources:

For product enquiries, device manuals, brochures and our official agents in your country: www.adc.co.uk

Follow us on our social media platforms:

Video tutorials: YouTube: https://www.youtube.com/@adcbioscientificltd2784

News and updates: X.com (formerly Twitter): @ADC_Biosci

Facebook: https://www.facebook.com/adcbioscientific

Application Notes available include:

- “Setting the timing of closed mode measurements with an ACE Station”
- “ACE Station operates for up to 28 days from a single 40Ah battery”
- “Extracting gas samples from an ACE Station for the analysis of soil CH_4 and N_2O flux”
- “Extending the air inlet to prevent water ingress (in areas prone to flooding)”
- “Measuring CO_2 efflux from agricultural soil”

Options and Accessories:

At ADC BioScientific, we recognise that every application is unique and has specifications, such as the ability to extract gases from the soil chamber for laboratory analysis. We are always willing to discuss such requirements.

A comprehensive range of the most commonly required accessories are available for ACE Stations and ACE Networks.

- Transit case
- Mains supply kit with 50m DC power cable
- 100m DC power lead for use with 1 ACE Station
- Soil moisture sensors by Delta T Devices
- Soil temperature thermistor probes
- Additional soil chambers

Comprehensive installation kits, spares kits and manuals are supplied as standard.

Courtesy of The University of Vermont, Kenya

For the investigation of plant, soil and atmospheric interactions, ADC BioScientific Ltd. expertly produce a wide range of portable, user-friendly and cost-effective devices, from photosynthesis to soil respiration systems. We are committed to enabling carbon cycle research worldwide through quality instrumentation and local, technical support.

ADC BioScientific Ltd. also supply: Portable Photosynthesis Systems, Leaf Area Meters, Chlorophyll Content Meters, Advanced Fluorometers, Automated Soil CO_2 Exchange Systems, Portable Soil Respiration Systems and Field Gas Analysers.

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Technical Specifications

ACE Station

Measurement of CO_2:	Standard range nominally 40mmol m^{-3} (0-896ppm at standard temperature and pressure) 0.05mmol m^{-3} resolution (1ppm). Infrared gas analyser housed directly adjacent to soil chamber. Differential open or closed system.
Measurement of PAR:	0 - 3000µmol m^{-2} sec^{-1}. Silicon photocell
Measurement of soil temperature:	6 selectable inputs for thermistors
Measurement of soil moisture:	4 selectable inputs for commercially available sensors.
Flow control to chamber:	200ml to 5L min^{-1}
Flow control accuracy:	+/- 3% of FSD
Display:	240 x 64 dot matrix LCD
Programming:	Each ACE station has a user-friendly interface driven by only 5 keys
Recorded data:	Removable SD card. Micro USB port.
Internal battery:	12V standby 1.0Ah battery back up (Networked Station only)
Power supply:	External battery, solar panel or wind turbine. One 40Ah car battery provides power for ca.28 days of continuous use
RS232 output:	User selectable rates of up to 19200 baud
Electrical connections:	Robust, waterproof 3 pin and 5 pin RS232
Dimensions:	82 x 33 x 13 cm
Closed chamber volume:	2.6L
Open chamber volume:	1.0L
Soil collar diameter:	23cm
Weight:	9.0 kg

Master Control Unit

Construction:	Steel electrically sealed enclosure
Electrical Connections:	30 ACE Station docking ports
Display:	Graphic 240 x 64 dot matrix LCD
Programming:	User-friendly interface driven by only 5 keys
Recorded data:	Dual Compact Flash card drive
RS232 output:	User selectable rates of up to 19200 baud
Power connection:	100 - 240 VAC. Dual 12V battery ports.
Dimensions:	40 x 40 x 20 cm
Weight:	12.0 kg